NETWORKS IN THE RIGHT SIDE OF THE HEART

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Delicate networks occur in the right side of the heart at three sites: at the entry of the inferior vena cava into the atrium, at the mouth of the coronary sinus, and between the endocardial surfaces of the right ventricle. The first clear account of the fenestrated valve of the inferior vena cava and coronary sinus was by Eustachi (1563, quoted by Franklin 1948). Franklin (1948) has reviewed the historical background of these valves and the theories concerned with their origin and function. Chiari (1879) described networks formed from the valves of the inferior vena cava, and in some cases of the coronary sinus, which showed attachments beyond the usual territories of these valves. These reticular formations are now called Chiari networks. Chiari himself considered them to act as a source of pulmonary emboli. Yater (1929) suggests that they may serve as a filter for emboli arriving at the right atrium from elsewhere in the venous system. This investigation is mainly concerned with the view that the network may act as a short circuit from sinu-atrial node to atrio-ventricular bundle.

Hearts from 300 consecutive necropsies were examined for the presence of networks in the right atrium and in the right ventricle. Of these 260 were from adults, 23 of whom were below the age of fifty; 7 were from children in the first five years of life; and 33 were from stillbirths and neonates.

Results

In 58 of all hearts examined, of which 38 were from children of five years or less, no valves were found of either the coronary sinus or the inferior vena cava. In 204 of 260 adult hearts examined the commonest findings were along the lateral border of the coronary sinus and in order of frequency could be divided into: (*a*) a conspicuous crescentic valve flap often fenestrated, (*b*) a valve flap that completely covered the orifice of the coronary sinus and was adherent to its medial wall except at one or two points, and (*c*) a single strand which was present alone in 25, or in association with a fenestrated valve of the inferior vena cava in 9 (Fig. 1). If the inferior sinus septum (Fig. 1) was absent or poorly developed, then the strands were continuous with a fenestrated valve of the inferior vena cava in five cases (Fig. 2).

The next most frequent abnormality found in 75 cases was a fenestrated valve of the inferior vena cava (Fig. 1). In four cases the attachments of this valve extended up to the internal orifice of the superior vena cava and inferiorly to the atrioventricular ring near the site, anterior to the coronary sinus, of the atrioventricular node (Fig. 3). Such a valve with these attachments is called the Chiari network (Yater, 1929). Evidence will be presented to support the desirability of distinguishing it from a fenestrated valve of the inferior vena cava without such attachments.

The degree of fenestration of the valve of the inferior vena cava was variable. The simplest form was a fleshy crescentic valve with a few holes in its free border (Fig. 1) whereas the extreme degree of fenestration was the Chiari net.

In eight hearts a network was found closely applied, and for the greater part adherent, to the postero-inferior part of the fossa and annulus ovalis (Fig. 4). Finally networks were found joining

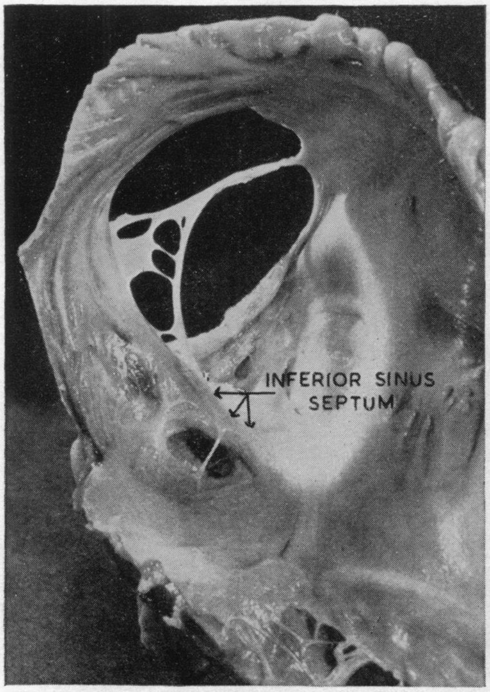

FIG. 1.—Fenestrated valve of the inferior vena cava (I.V.C.) and strand-like valve of coronary sinus.

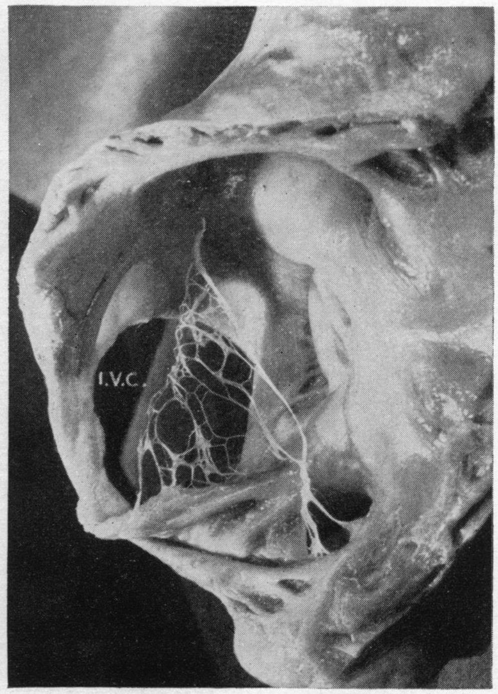

FIG. 2.—Continuity of valve of I.V.C. and coronary sinus due to absent inferior sinus septum.

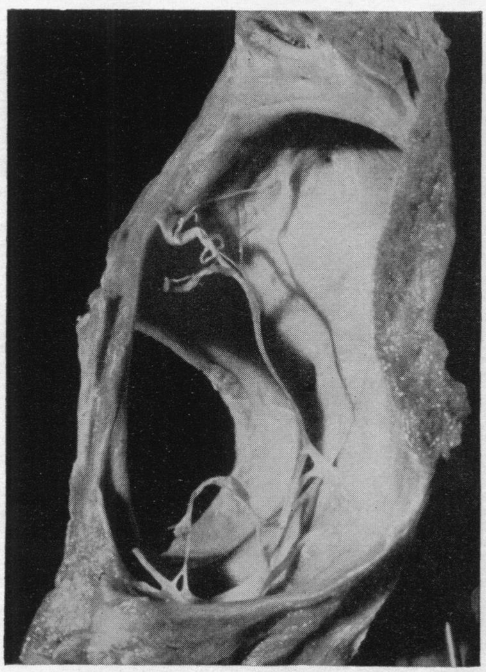

FIG. 3.—Network of Chiari stretching across the opening of the I.V.C. into the atrium.

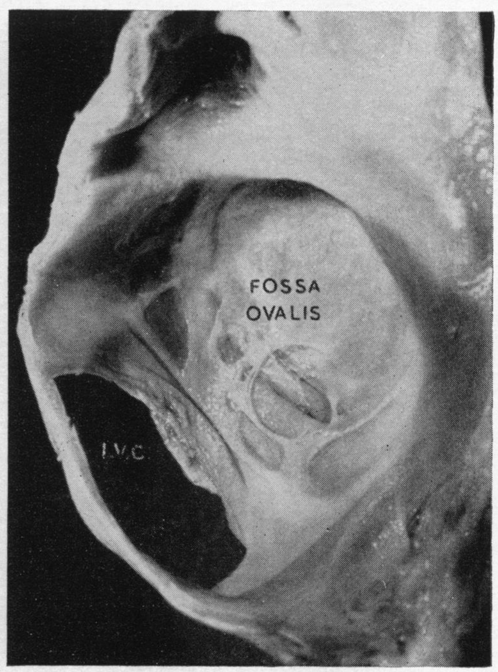

FIG. 4.—Remnants of the left valve of the sinus venosus on the medial wall of the right atrium.

the lateral wall of the right ventricle to the ventricular septum in 31 cases; these are usually situated towards the base of the heart and are not significantly associated with either presence or absence of the moderator band of the ventricle (Fig. 5).

Sections were prepared of atrial and ventricular networks and stained with hæmatoxylin and eosin and by Weigert's resorcin fuchsin method for elastic tissue. Strands of cardiac muscle were found in all networks (Fig. 6) and were surrounded by strands of elastic tissue, a feature noted by

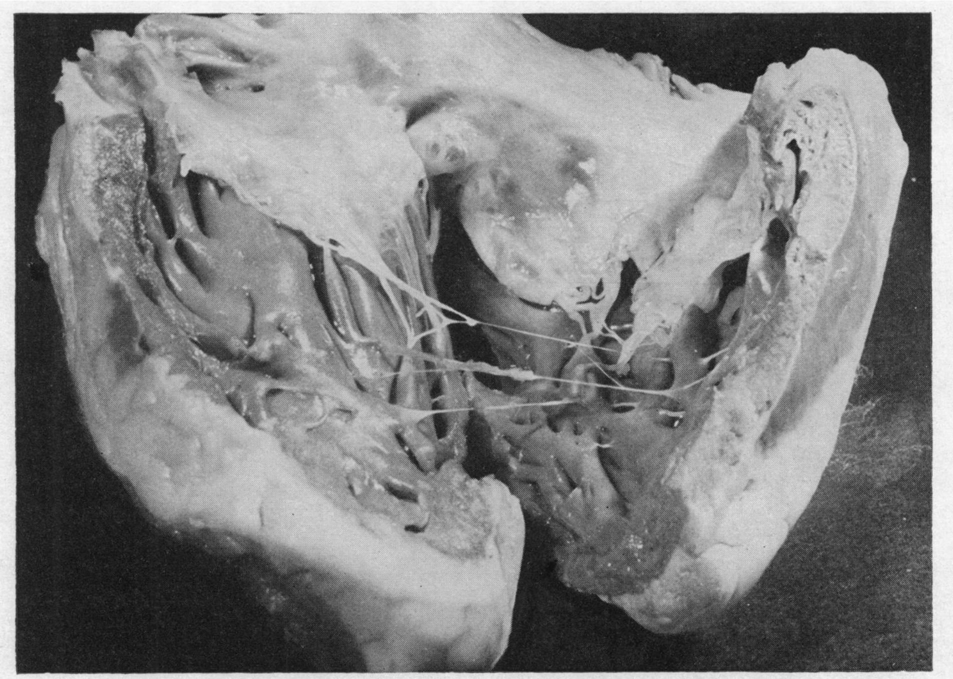

FIG. 5.—Delicate strands crossing the right ventricle.

FIG. 6.—Strands of cardiac muscle in the network of Chiari (× 20).

Benninghoff (1930, quoted by Franklin, 1948). In a study of the conducting system of 94 hearts the author has also noted this close association of elastic fibres with the conducting tissue particularly of the sinu-atrial node and of the Purkinje branches in the ventricles; he considers it to be a more useful means of identification of the tissue than the morphology of the fibres themselves.

The following three case reports illustrate the part which these networks may play in disease.

Case 1 (F. 78). Admitted to hospital with seven days' history of anorexia and five days' pain in the right illiac fossa. A laparotomy was performed and the vermiform appendix removed. Six days later she became comatose, developed a right hemiplegia, and died.

Necropsy. Coiled thrombi were found in the right and left main pulmonary trunks. Recent thrombi were found in veins of the right calf. A recent thrombus filled the left common carotid artery and its internal carotid branch up to the middle cerebral artery. The brain showed a recent left cerebral infarct and a recent infarct was present in the right kidney, which was surrounded by an abscess containing 20 ml. of pus.

The significant findings in the heart were a patent foramen ovale (about 12 mm. in diameter) and a Chiari network in which was tangled ante mortem thrombus (Fig. 7).

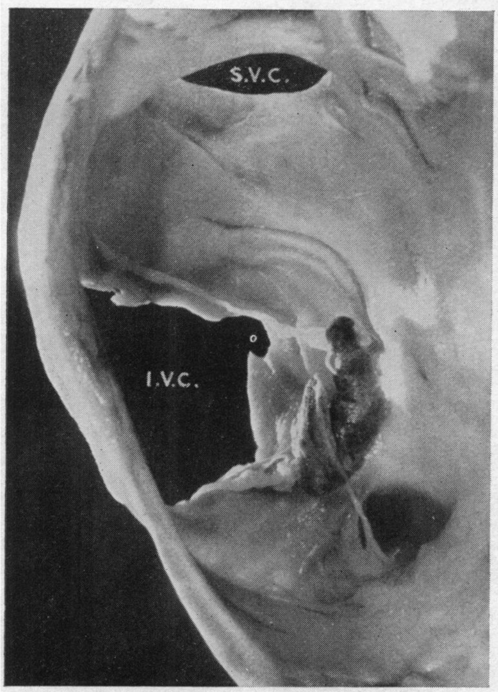

FIG. 7.—Recent thrombus tangled in the valve of the inferior vena cava.

Case 2 (F. 46). Suffered from attacks of dyspnœa for the four weeks before admission to hospital. One week before she had a severe attack while walking home. Cough had been present for one week. On examination she was found to be orthopnœic and deeply cyanosed. The neck veins were engorged to the angle of the jaw when sitting upright. An electrocardiogram taken on the third day after admission showed evidence of a recent pulmonary embolus with enlargement and peaking of P waves. An interesting feature was the variation in P–R interval.

Following three successive attacks of dyspnœa with loss of consciousness, the patient died on the fourth day after admission.

Necropsy. Old adherent thrombus filled the left main pulmonary artery and more recent thrombus the right. Moderately old thrombus filled the left iliac, popliteal, and tibial veins.

The relevant finding in the heart was a Chiari network (Fig. 8) extending from the site of the sinu-atrial node to a point just anterior to the atrio-ventricular node. The foramen ovale was valvular (about 0·5 cm. diameter).

Case 3 (F. 66). Found dead at home. There was no history of previous ill-health.

Necropsy. A recent antero-lateral and anterior septal cardiac infarct was present. A Chiari network was found in the right atrium (Fig. 3). A recent thrombus was found in the branch of the pulmonary artery to the right lower lobe. This was most probably embolic though no source of thrombi could be found in either leg veins or in the heart itself.

Comment. These three cases illustrate the inadequacy of the Chiari net as a filter for pulmonary emboli. One embolus by becoming entangled in it, completely destroys its filtering effect and allows further emboli to enter the pulmonary artery and also to pass through a patent foramen ovale (Case 1).

The variation of the P–R interval in Case 2 is most probably due to a shifting pacemaker, but could also be explained by supposing that the Chiari net provided an alternative path for the cardiac impulse.

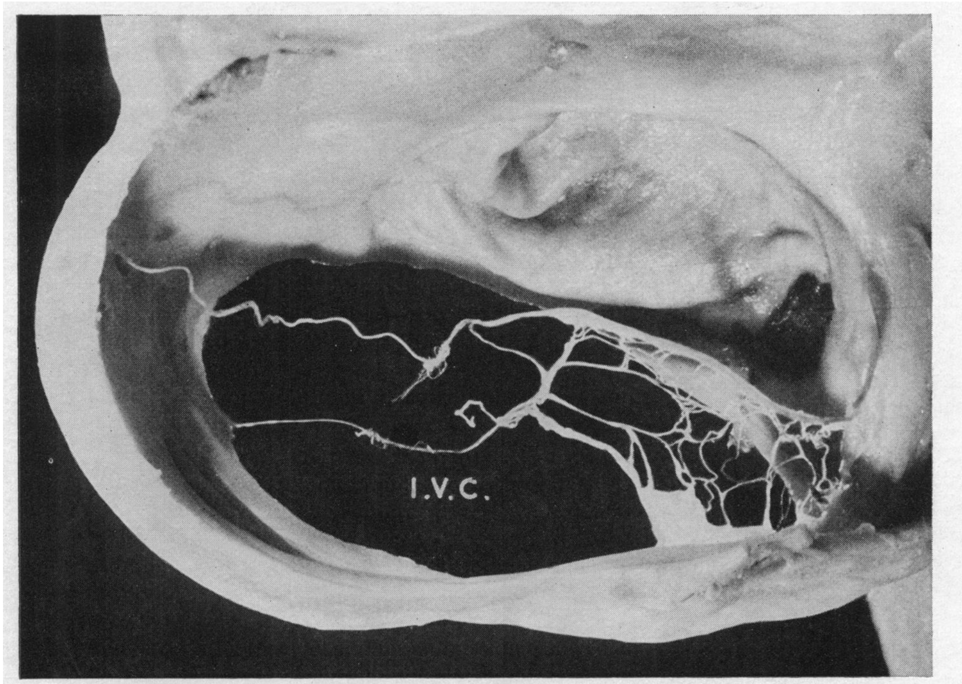

FIG. 8.—Chiari net, showing strands extending from the region of the S.A. node (on the left) to region of A.V. node (on right).

DISCUSSION

These networks present problems concerning their source of origin and their functional significance. Of the 30 hearts from children and infants, only one, an anencephalic, showed a valve of the inferior vena cava and yet in the adult hearts some sort of valve was found in 57 out of 260. It is difficult to believe that fenestrated valves of the inferior vena cava arise as a result of degeneration in previously intact valves. The valve of the inferior vena cava and the networks on the medial wall of the right atrium (Fig. 4) are now considered to arise from the right and left lips of the sinus venosus in the embryo. Their origin from atrial wall is supported by the finding of cardiac muscle fibres in their substance, but the discrepancy between the findings in the child and in the adult are difficult to explain except on the basis of the altering relationships of cardiac structures with growth. Such a discrepancy may not be of statistical significance in the present series and is also open to the criticism that these delicate structures may have been overlooked in the small infant heart. Such oversight can be prevented by dividing the inferior vena cava close to its pericardial reflection when removing the heart, so that the valve is not cut across, and also by teasing the orifice of the vena cava under a gentle stream of water so that the valve, if it has rolled up into a strand, will unravel and become visible. Such precautions were taken in all the cases examined in this series.

Various views have been expressed about the function of these networks. It has been considered that the valve acts mechanically by preventing blood from the superior vena cava entering the inferior vena cava, or in fœtal life by directing inferior caval blood through the foramen ovale. There is little evidence to support the idea that they may act as a source of or a filter for pulmonary emboli. Chiari's first case of a young man dying with pulmonary embolism, the only source of which was the atrial network, is insufficiently documented. The two cases quoted here illustrate the inadequacy of the network as a filter for emboli since the first embolus to become entangled in it renders it ineffective for further emboli.

Another idea that this network may conduct the cardiac impulse was initiated by Gatzi (1929) who described Purkinje tissue in them. Jordan (1926) suggested that it might serve as a path for the wave of atrial flutter.

The differentiation of Purkinje tissue from cardiac muscle is difficult (Glomset and Birge, 1948). The presence of elastic strands around each Purkinje fibre and around groups of fibres has been a distinguishing feature in the author's unpublished series. Such fibres were found at sites where conducting tissue was seen in the heart of an ox in which conducting tissue is easily differentiated from cardiac muscle. Field (1951) has revived the view that the conduction of the cardiac impulse is by nerves alone; it has not, to date, been possible to refute this idea and is as reasonable an explanation of the conduction of the cardiac impulse as is the conducting system itself. Purkinje tissue was not found in sections of networks, but cardiac muscle and nerve fibres were found. They may, therefore, provide an alternative path for the cardiac impulse from sinu-atrial node to atrio-ventricular bundle, or even to the septal muscle itself.

The variations of P–R interval in Case 2 could be explained by conduction down the Chiari net which linked the region of the S-A node to the atrio-ventricular bundle. The QRS complexes were not unduly broadened so that one may assume that ventricular excitation was normal. Such a network may in part explain the syndrome of Wolff, Parkinson, and White; opportunities to test this hypothesis at necropsy are rare. The varying tension that may develop in the network with changing venous pressure in the atrium would also provide a more feasible explanation of the intermittent character of the conduction defect than does the bundle of Kent which runs over the atrioventricular ring, the least distensible part of the heart.

The significance of the presence or otherwise of a valve of the coronary sinus is obscure. The delicate strands crossing the right ventricle may play a part in cardiac function as a conducting tissue; Tawara (1906) has described tendon-like strands containing conducting tissue crossing the cavity of the left ventricle.

It seems desirable to retain the term Chiari network for those valves of the inferior vena cava having attachments near the sinu-atrial node and along the course of the atrio-ventricular bundle, as they may play a part in short circuiting the atrio-ventricular node and provide a path for the atrial impulse which is shorter than that normally followed.

SUMMARY

The incidence of networks in the right atrium and ventricle in 300 hearts is reported.

These networks contain cardiac muscle and may provide an alternative path for the passage of the impulse from sinu-atrial node to ventricle.

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